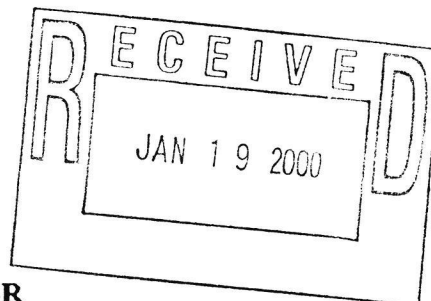


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**GEOPROBE™ GROUNDWATER
INVESTIGATION REPORT**

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RCAP

October 1996

Prepared for

American Cyanamid, Inc.
P.O. Box 817
Hannibal, Missouri 63401

Prepared by

Geraghty & Miller, Inc.
5100 E. Skelly Drive, Suite 1000
Tulsa, Oklahoma 74135
(918) 664-9900



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GERAGHTY & MILLER, INC.




TABLES

FIGURES

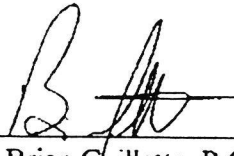
GEOPROBE™ GROUNDWATER INVESTIGATION REPORT

October 1996

Prepared by GERAGHTY & MILLER, INC.



Eric M. Rainey, P.G.
Hydrogeologist/Project Manager



Brian Guillette, P.G.
Associate/Office Manager



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1. Summary of Detected Volatile Organic Compounds (VOCs) in Groundwater Samples Collected from Geoprobe™ Borings and Selected Onsite Production Wells, American Cyanamid, Inc. Facility, Hannibal, Missouri.

FIGURES

1. Site Location Map.
2. Site Map with Geoprobe™ Locations.
3. Monochlorobenzene Concentrations in Geoprobe™ Groundwater Samples.
4. Ethylene Dichloride (1,2-DCA) Concentrations in Geoprobe™ Groundwater Samples.



APPENDICES

- A. Groundwater Analytical Data.
- B. Vertical Profile Graphs of 1,2-DCA Concentrations.



GEOPROBE™ GROUNDWATER INVESTIGATION REPORT

1.0 INTRODUCTION

1.1 PURPOSE AND OBJECTIVE

This report has been prepared for American Cyanamid, Inc. by its consultant Geraghty & Miller, Inc., to relate the findings of a Geoprobe™ groundwater investigation conducted in December 1995 and January 1996 at the American Cyanamid Facility, located near Hannibal, Missouri. The purpose and objective of the investigation was to identify and delineate the presence of volatile organic compounds (VOCs) associated with onsite water supply wells (i.e. production wells) PW-7, PW-8, and PW-9. VOCs detected in the production wells include ethylene dichloride (EDC) and monochlorobenzene (MCB), both of which have been used as process chemicals at the facility. This report describes the results of all field and laboratory activities. The scope of work was conducted in accordance with the proposal addendum for hydrogeological investigation submitted to American Cyanamid on September 28, 1994.

1.2 SITE DESCRIPTION

The American Cyanamid facility is located on the west bank of the Mississippi River approximately 10 miles north of Hannibal, Missouri (Figure 1). The site property consists of approximately 2000 acres located within Sections 10, 11, 14, 15, 22, and 23, Township 3 South, Range 5 West. The site is part of the South River Industrial Levee Subdistrict of the South River Drainage District. The facility is a modern agricultural chemicals plant which produces pesticides. In the late 1960's and 1970's, the facility also produced and stored ammonium nitrate and nitric acid and has operated at its present location since 1965.

The site is located in an industrial/agricultural area and is bordered by Mississippi River to the east, agricultural land to the south and west; and a large power plant (i.e. Northeast Missouri Electric Power Cooperative) to the north. The plant maintains a total of 14 production wells



located on the site property for process purposes. Groundwater derived from Wells PW-7, PW-8, and PW-9 is routed directly to one of four onsite incinerators used as scrubbers.

1.3 ENVIRONMENTAL SETTING

The American Cyanamid facility is located on the west bank of the Mississippi River at an elevation of approximately 460 to 470 feet (ft) above mean sea level (MSL). The topography of the site is characterized as relatively flat, surrounded by flood levees. Surface water drainage at the site is generally from north to south in the absence of a formal drainage ditch system.

The unconsolidated geologic deposits underlying the site consist of approximately 10 to 15 ft of gray, stiff, silty clay, underlain by a thick deposit (approximately 160 ft) of fine to coarse alluvial sand with some gravel. Bedrock is encountered approximately 175 ft below ground surface (BGS) and consists primarily of limestone of lower Mississippian age. Depth to groundwater is relatively shallow and exists under water table conditions (i.e. unconfined aquifer). During times of elevated river stages, groundwater at the site may exist under semi-confined conditions. Importantly, the depth to groundwater is directly influenced by fluctuations in the Mississippi River stage.



2.0 METHODOLOGIES

2.1 GEOPROBE™ INSTALLATION AND SAMPLING PROCEDURES

A total of fifty (50) 1-inch diameter, Geoprobe™ borings were installed at the site in December 1995 and January 1996 by Hydro-Logic, Inc. of Eudora, Kansas. The Geoprobe™ installation and sampling activities at the American Cyanamid facility was undertaken in two phases. The first phase of the investigation was performed December 11-16, 1995, and included the installation of 23 Geoprobe™ borings focused on the area in the vicinity of Wells PW-7, PW-8, and PW-9. The second phase of the investigation was performed January 15-19, 1996, and included the installation of 27 additional Geoprobe™ borings focused on the central and southern sectors of the plant. Actual Geoprobe™ locations were determined in the field by the onsite Geraghty & Miller field supervisor in conjunction with American Cyanamid personnel. Geoprobe™ sampling locations are illustrated on Figure 2.

The one-inch diameter, hollow steel rods were hydraulically driven into the subsurface to the desired depth or until refusal. The steel probe rods are 3 ft in length and are threaded on the ends for easy connection. An expendable drive point is located on the end of the probe. Once the desired sampling depth (80 to 90 ft BGS) or refusal was encountered, the steel rods were retracted approximately 0.5 ft to 1 ft to drop the expendable drive point, thus allowing groundwater to flow into the hollow rods. Teflon tubing (1/4 inch diameter) was inserted into the hollow rods to allow for collection of grab groundwater samples with a peristaltic pump. The groundwater samples were placed in 40 milliliter (mL) glass vial(s) for subsequent analysis.

Two Geoprobe™ locations were utilized to gather vertical profile data (GW-43 and GW-45). The vertical profiles were completed in a multiple boring fashion with each boring being located less than six inches apart. Groundwater samples were collected at approximately 20 ft intervals throughout the total depth of the boring.



Following collection of the groundwater sample, the hollow steel rods were removed from the subsurface and the borehole was closed by filling with a bentonite grout.

2.2 LABORATORY ANALYTICAL PROCEDURES

2.2.1 On-site Analyses

A minimum of one groundwater sample collected from each Geoprobe™ location was analyzed onsite by Hydro-Logic Inc.'s mobile laboratory. Approximately 20 mL of sample was placed in a 40 mL glass vial and heated to approximately 60 degrees Centigrade ("C). Headspace gases were then injected into the gas chromatograph (GC) for analysis of volatile organic compounds (VOC's) by U.S. Environmental Protection Agency (USEPA) Method 8021.

2.2.2 Other Laboratory Analyses

A total of eight (8) duplicate groundwater samples (GW-16, GW-17, GW-18, GW-20, GW-34, GW-37, GW-41, and GW-43) were collected from selected Geoprobe™ locations for subsequent submittal to an analytical laboratory. The duplicate groundwater samples were split in the field, placed in laboratory-supplied bottles, and placed on ice for shipment to Inchcape Testing Services, located in Richardson, Texas. These samples were analyzed for VOC's by USEPA Method 8240. Duplicate samples were collected to verify the results from the onsite mobile laboratory.

2.3 DECONTAMINATION PROCEDURES

A decontamination staging area was prepared at a designated on-site location. All sampling equipment was cleaned prior to initiating the field activities, and between each Geoprobe™ boring. The steel rods and associated tools were decontaminated by using a non-phosphate detergent and distilled water solution. Standard Geraghty & Miller quality assurance/quality control protocols were maintained during all field sampling activities.



3.0 GROUNDWATER ANALYTICAL RESULTS

3.1 MONOCHLOROBENZENE OCCURRENCE

Monochlorobenzene (MCB), also referred to as chlorobenzene, was detected above the laboratory reporting limit in groundwater samples collected from 22 of 50 Geoprobe™ locations. MCB was also detected above the laboratory reporting limit in Wells PW-7 and PW-8. Results of the MCB data are summarized on Table 1, along with a comparison summary of mobile GC and laboratory verification groundwater analyses. The analytical reports are presented in Appendix A. The analytical data can be summarized as follows:

- Detectable concentrations of MCB in groundwater samples collected from Geoprobe™ locations ranged from 3.02 micrograms per liter (µg/L) in Sample GW-18 to 1,360 µg/L in Sample GW-41DUP. The highest concentrations of MCB were located in the southeastern sector of the plant, immediately south of the aboveground bulk storage tank area.
- MCB was detected in groundwater samples collected from Wells PW-7 and PW-8 at concentrations of 21.40 µg/L and 42.25 µg/L, respectively.

3.2 ETHYLENE DICHLORIDE OCCURRENCE

Ethylene Dichloride (EDC), also referred to as 1,2-dichloroethane (1,2-DCA) was detected above the laboratory reporting limit in groundwater samples collected from 44 of 50 Geoprobe™ locations. 1,2-DCA was also detected in groundwater samples collected from Wells PW-7 and PW-8. Graphs illustrating concentrations of 1,2-DCA in a vertical profile collected from Geoprobe™ locations GW-43 and GW-45 are provided in Appendix B. Results of the 1,2-DCA data are summarized on Table 1, along with a comparison summary of mobile GC and laboratory verification groundwater analyses. The analytical reports are presented in Appendix A. The analytical data can be summarized as follows:



- Detectable concentrations of 1,2-DCA in groundwater samples collected from Geoprobe™ locations ranged from 8.80 µg/L in Sample GW-47 to 7,970 µg/L in Sample GW-41DUP. The highest concentrations of 1,2-DCA were located in the southcentral and southeastern sectors of the plant.
- 1,2-DCA was detected in groundwater samples collected from Wells PW-7 and PW-8 at concentrations of 30.59 µg/L and 613 µg/L, respectively.
- 1,2-DCA detected in groundwater samples collected at Geoprobe™ locations GW-43 and GW-45 (vertical profile locations) indicate an overall decrease in concentrations with depth.

3.3 OTHER DETECTABLE VOCs

Other detectable VOCs in groundwater samples collected from Geoprobe™ locations included 1,1-Dichloroethane (1,1-DCA), chloroform, trans-1,2-Dichloroethene (trans-1,2-DCE), ethylbenzene, and xylenes. None of these constituents were detected in groundwater samples collected Water Supply Wells PW-7, PW-8, and PW-9. Results of the other detectable VOCs are summarized on Table 1, along with a comparison summary of mobile GC and laboratory verification groundwater analyses. The analytical reports are presented in Appendix A. The analytical data can be summarized as follows:

- 1,1-DCA was detected above the laboratory reporting limit in 7 of 50 groundwater samples collected from Geoprobe™ locations. Detectable concentrations ranged from 5.6 µg/L in Sample GW-37DUP to 53.98 µg/L in Sample GW-12.
- Chloroform was detected above the laboratory reporting limit in 5 of 50 groundwater samples collected from Geoprobe™ locations. Detectable concentrations ranged from 20.25 µg/L in Sample GW-11 to 169.94 µg/L in Sample GW-13.



- trans-1,2-DCE was detected above the laboratory reporting limit in 1 of 50 groundwater samples collected from Geoprobe™ locations. Sample GW-13 had a detectable concentration of 27.95 µg/L.
- Ethylbenzene was detected above the laboratory reporting limit in 1 of 50 groundwater samples collected from Geoprobe™ locations. Sample GW-14 had a detectable concentration of 342 µg/L.
- Xylenes (total) were detected above the laboratory reporting limit in 3 of 50 groundwater samples collected from Geoprobe™ locations. Detectable concentrations ranged from 6.06 µg/L in Sample GW-43 to 2,164 µg/L in Sample GW-14.



4.0 SUMMARY

In summary, the following observations are noted:

- The presence of 1,2-DCA was detected in groundwater samples collected from 44 of 50 Geoprobe™ locations and Wells PW-7 and PW-8. A maximum concentration of 7970 µg/L was detected in the groundwater sample collected from GW-41DUP, located in the southcentral sector of the plant.
- The presence of MCB was detected in groundwater samples collected at 22 of 50 Geoprobe™ locations and Wells PW-7 and PW-8. The maximum MCB concentration detected in the groundwater was 1,360 µg/L (Sample GW-41DUP). The highest concentrations of MCB are located in the southeastern sector of the plant.
- Other VOCs detected in the groundwater included 1,1-DCA, trans-1,2-DCE, and chloroform. 1,1-DCA was detected in groundwater samples collected from 7 of 50 groundwater locations, with a maximum concentration of 53.98 µg/L (Sample GW-12). The compound trans-1,2-DCE was detected in the groundwater at 1 of 50 Geoprobe™ locations, with a maximum concentration of 27.95 (Sample GW-13). Lastly, chloroform was detected in the groundwater at 5 of 50 Geoprobe™ locations, with a maximum concentration 169.94 µg/L (Sample GW-13). All three of these constituents were detected in areas associated with the presence of 1,2-DCA and MCB.

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Table 1. Summary of Detected Volatile Organic Compounds (VOCs) in Groundwater Samples Collected from Geoprobe Borings and Selected Onsite Production Wells, American Cyanamid, Inc. Facility, Hannibal, Missouri.

Sample ID	Depth Collected (ft bls)	Date Collected	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	EDC (1,2-DCA) (µg/L)	MCB (µg/L)	1,1-DCA (µg/L)	Chloroform (µg/L)	trans-1,2-DCE (µg/L)
GW-1	68	12/11/95	<5.0	<5.0	<2.0	<2.0	<2.0	<2.0	<2.0
GW-2	80	12/11/95	<5.0	<5.0	<2.0	<2.0	<2.0	<2.0	<2.0
GW-3	80	12/12/95	<5.0	<5.0	<2.0	<2.0	<2.0	<2.0	<2.0
GW-4	80	12/12/95	<5.0	<5.0	454	19.99	21.01	30.32	<2.0
GW-5	80	12/12/95	<5.0	<5.0	369	37.38	<2.0	<2.0	<2.0
GW-6	80	12/12/95	<5.0	<5.0	55.05	35.24	<2.0	<2.0	<2.0
GW-7	70	12/12/95	<5.0	<5.0	116	<2.0	<2.0	<2.0	<2.0
GW-8	80	12/12/95	<5.0	<5.0	17.20	218	<2.0	<2.0	<2.0
GW-9	89	12/14/95	<5.0	<5.0	245	54.58	<2.0	<2.0	<2.0
GW-10	89	12/14/95	<5.0	<5.0	236	735	<2.0	<2.0	<2.0
GW-11	60	12/14/95	<5.0	<5.0	796	40.02	13.58	20.25	<2.0
GW-12	89	12/14/95	<5.0	<5.0	1441	693	53.98	146	<2.0
GW-13	70	12/14/95	<5.0	<5.0	2385	68.32	44.13	169.94	27.95
GW-14	89	12/14/95	342	2164	643	9.17	<2.0	<2.0	<2.0
GW-15	89	12/15/95	<5.0	<5.0	<2.0	<2.0	<2.0	<2.0	<2.0
GW-16	89	12/15/95	<5.0	<5.0	19.67	<2.0	<2.0	<2.0	<2.0
GW-16 DUP	89	12/15/95	<5.0	<5.0	19.90	<2.0	<2.0	<2.0	<2.0
GW-17	58	12/15/95	<5.0	<5.0	690	954	<2.0	<2.0	<2.0
GW-17 DUP	58	12/15/95	<5.0	<5.0	303	594	<2.0	<2.0	<2.0

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Table 1. Summary of Detected Volatile Organic Compounds (VOCs) in Groundwater Samples Collected from Geoprobe™ Borings and Selected Onsite Production Wells, American Cyanamid, Inc., Facility, Hannibal, Missouri.

Sample ID	Depth Collected (ft bls)	Date Collected	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	EDC (1,2-DCA) (µg/L)	MCB (µg/L)	1,1-DCA (µg/L)	Chloroform (µg/L)	t-1,2-DCE (µg/L)
GW-18	89	12/15/95	<5.0	<5.0	6.56	3.02	<2.0	<2.0	<2.0
GW-18 DUP	89	12/15/95	<5.0	<5.0	149	62.6	<2.0	<2.0	<2.0
GW-19	89	12/15/95	<5.0	<5.0	2146	12.82	23.49	55.03	<2.0
GW-20	89	12/15/95	<5.0	<5.0	88.44	98.53	<2.0	<2.0	<2.0
GW-20 DUP	89	12/15/95	<5.0	<5.0	268	282	<2.0	<2.0	<2.0
GW-21	89	12/16/95	<5.0	<5.0	595	<2.0	<2.0	<2.0	<2.0
GW-22	89	12/16/95	<5.0	<5.0	<2.0	<2.0	<2.0	<2.0	<2.0
GW-23	89	12/16/95	<5.0	<5.0	11.89	<2.0	<2.0	<2.0	<2.0
GW-24	89	01/15/96	<10.0	<10.0	14.23	<4.0	<4.0	<4.0	<4.0
GW-25	87	01/15/96	<5.0	<5.0	<2.0	<2.0	<2.0	<2.0	<2.0
GW-26	89	01/15/96	<5.0	<5.0	<2.0	<2.0	<2.0	<2.0	<2.0
GW-27	89	01/15/96	<5.0	<5.0	51.04	<2.0	<2.0	<2.0	<2.0
GW-28	89	01/15/96	<5.0	<5.0	2084	<2.0	<2.0	<2.0	<2.0
GW-29	68	01/16/96	<25.0	<25.0	71.72	<10.0	<10.0	<10.0	<10.0
GW-30	68	01/16/96	<25.0	<25.0	702	<10.0	<10.0	<10.0	<10.0
GW-31	70	01/16/96	<10.0	<10.0	67.06	<4.0	<4.0	<4.0	<4.0
GW-32	75	01/16/96	<10.0	<10.0	10.56	<2.0	<4.0	<4.0	<4.0
GW-33	45	01/16/96	<5.0	56.75	1327	209	<2.0	<2.0	<2.0

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Table 1. Summary of Detected Volatile Organic Compounds (VOCs in Groundwater Samples Collected from Geoprobe™ Borings and Selected Onsite Production Wells, American Cyanamid, Inc., Facility, Hannibal, Missouri.

Sample ID	Depth Collected (ft bls)	Date Collected	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	EDC (1,2-DCA) (µg/L)	MCB (µg/L)	1,1-DCA (µg/L)	Chloroform (µg/L)	t-1,2-DCE (µg/L)
GW-34	67	01/16/96	<5.0	<5.0	500	54.83	<2.0	<2.0	<2.0
GW-34 DUP	67	01/16/96	<5.0	<5.0	1670	248	<2.0	<2.0	<2.0
GW-35	67	01/16/96	<5.0	<5.0	154	149	<2.0	<2.0	<2.0
GW-36	80	01/16/96	<5.0	<5.0	379	136	<2.0	<2.0	<2.0
GW-37	80	01/16/96	<5.0	<5.0	710	<2.0	<2.0	<2.0	<2.0
GW-37 DUP	80	01/16/96	<5.0	<5.0	4930	8.5	5.6	<2.0	<2.0
GW-38	80	01/17/96	<10.0	<10.0	16.25	<4.0	<4.0	<4.0	<4.0
GW-39	80	01/17/96	<10.0	<10.0	38.83	<4.0	<4.0	<4.0	<4.0
GW-40	74	01/18/96	<5.0	<5.0	76.69	<2.0	<2.0	<2.0	<2.0
GW-41	65	01/17/96	<10.0	<10.0	1287	211	<4.0	<4.0	<4.0
GW-41 DUP	65	01/17/96	<10.0	<10.0	7970	1360	26.6	<4.0	<4.0
GW-42	77	01/17/96	<10.0	<10.0	509	34.46	<2.0	<2.0	<2.0
GW-43	20	01/18/96	<5.0	6.06	1796	22.04	<2.0	<2.0	<2.0
GW-43	40	01/18/96	<5.0	<5.0	579	<2.0	<2.0	<2.0	<2.0
GW-43	60	01/18/96	<5.0	<5.0	54.32	<2.0	<2.0	<2.0	<2.0
GW-43	73	01/18/96	<5.0	<5.0	50.52	<2.0	<2.0	<2.0	<2.0
GW-43 DUP	73	01/18/96	<5.0	<5.0	47.6	<2.0	<2.0	<2.0	<2.0
GW-44	83	01/17/96	<10.0	<10.0	11.65	<4.0	<4.0	<4.0	<4.0
GW-45	20	01/17/96	<10.0	<10.0	13.64	<4.0	<4.0	<4.0	<4.0
GW-45	32	01/17/96	<10.0	<10.0	53.15	<4.0	<4.0	<4.0	<4.0
GW-45	60	01/17/96	<10.0	<10.0	<10.0	<4.0	<4.0	<4.0	<4.0
GW-45	84	01/17/96	<10.0	<10.0	10.01	<4.0	<4.0	<4.0	<4.0

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Table 1. Summary of Detected Volatile Organic Compounds (VOCs) in Groundwater Samples Collected from Geoprobe™ Borings and Selected Onsite Production Wells, American Cyanamid, Inc. Facility, Hannibal, Missouri.

Sample ID	Depth Collected (ft bls)	Date Collected	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	EDC (1,2-DCA) (µg/L)	MCB (µg/L)	1,1-DCA (µg/L)	Chloroform (µg/L)	trans-1,2-DCE (µg/L)
GW-46	80	01/17/96	<5.0	<5.0	15.02	<2.0	<2.0	<2.0	<2.0
GW-47	76	01/18/96	<5.0	<5.0	8.80	<2.0	<2.0	<2.0	<2.0
GW-48	74	01/19/96	<5.0	<5.0	44.32	<2.0	<2.0	<2.0	<2.0
GW-49	77	01/19/96	<5.0	<5.0	326	<2.0	<2.0	<2.0	<2.0
GW-50	81	01/19/96	<5.0	<5.0	652	<2.0	<2.0	<2.0	<2.0
PW-7	66-92 ⁽¹⁾	12/11/95	<5.0	<5.0	30.59	21.40	<2.0	<2.0	<2.0
PW-8	62-88 ⁽¹⁾	12/11/95	<5.0	<5.0	613	42.25	<2.0	<2.0	<2.0
PW-9	56-82 ⁽¹⁾	12/11/95	<5.0	<5.0	<2.0	<2.0	<2.0	<2.0	<2.0
1994 Missouri Water Quality Standards for Groundwater			700	10,000	5	100	—	100	100

ft bls Feet below land surface.
 DUP Duplicate sample.
 (1) Refers to the screened interval of the well.
 µg/L Micrograms per liter; equivalent to parts per billion (ppb).
 EDC Ethylene dichloride, also known as 1,2-dichloroethane (1,2-DCA).
 MCB Monochlorobenzene or chlorobenzene.
 1,1-DCA 1,1-dichloroethane
 trans-1,2-DCE trans-1,2-dichloroethene

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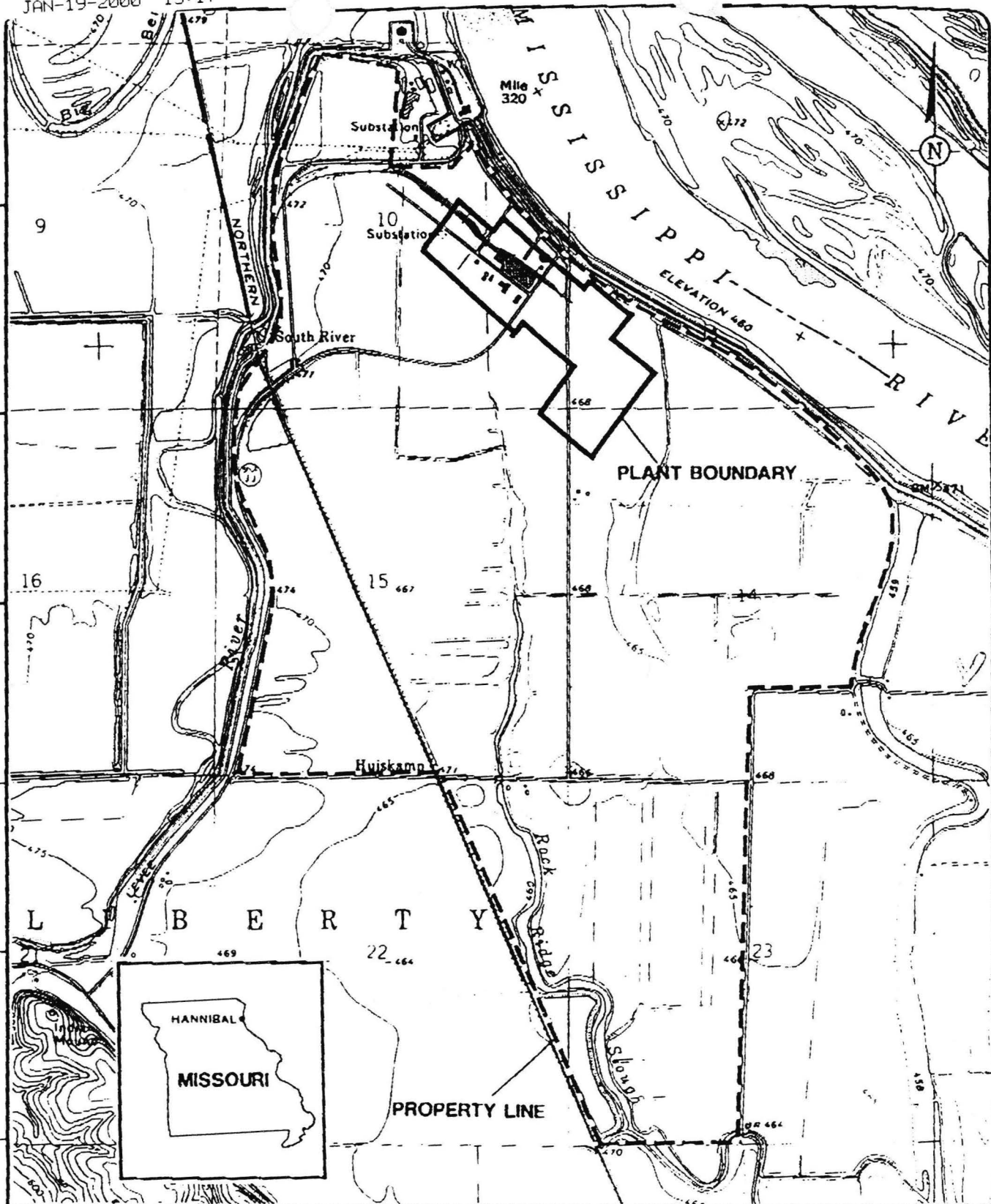
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CHECKED: ERIC RAINEY

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**GERAGHTY
& MILLER, INC.**
Environmental Services

A Heidemij Company

0 2000 FT.

SITE LOCATION MAP REF. USGS 7.5' QUADRANGLE - QUINCY SW, MO/ILL.

AMERICAN CYANAMID FACILITY
HANNIBAL, MISSOURI

FIGURE

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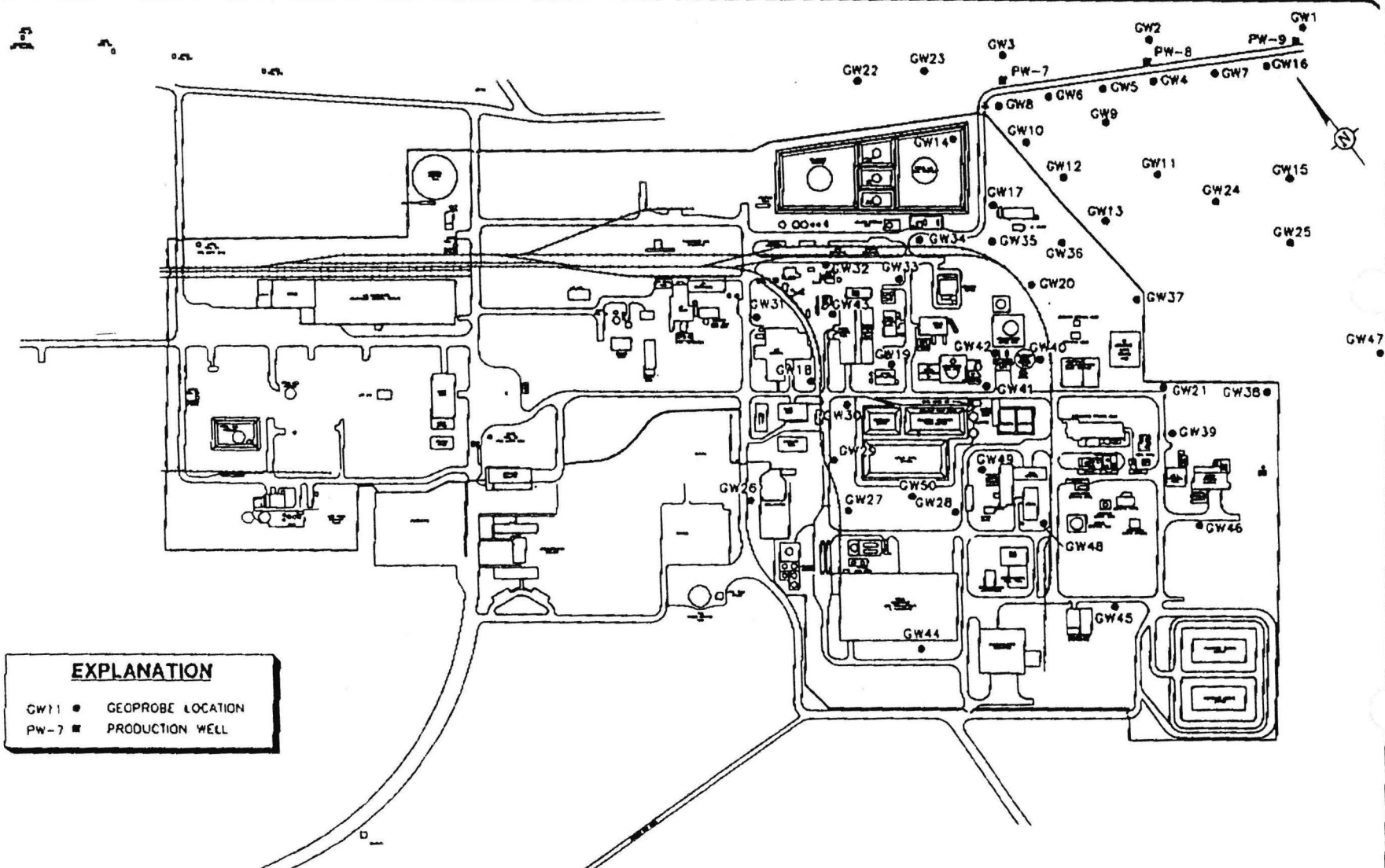
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CHECKED: MIKE DWYER

APPROVED: ERIC RAINEY

DRAFTER: JIM HARBESTON



**GERAGHTY
& MILLER, INC.**
Environmental Services

A Heidemij Company

0 500 FT.

SITE MAP WITH GEOPROBE LOCATIONS

AMERICAN CYANAMID INC. FACILITY
HANNIBAL, MISSOURI

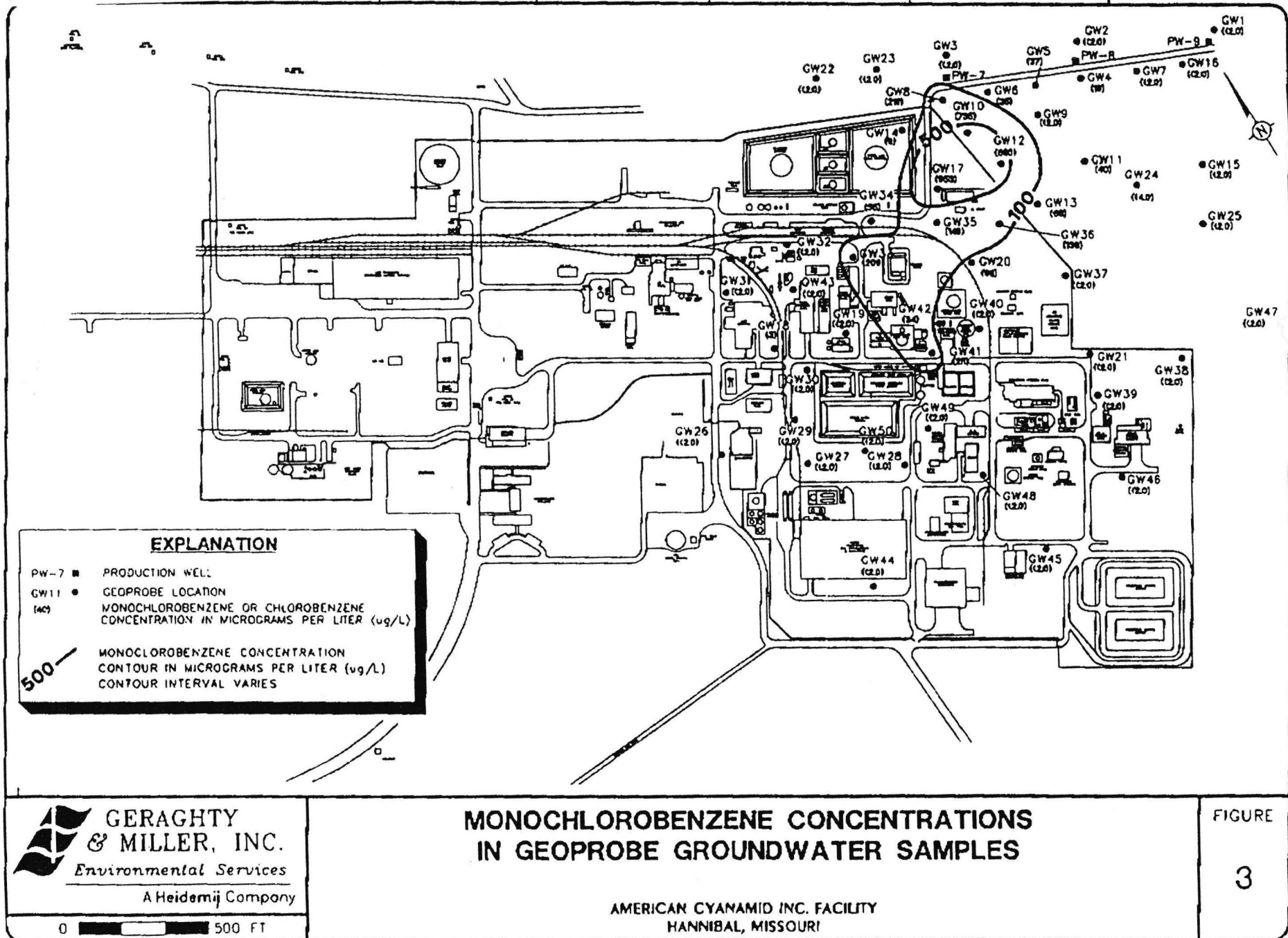
FIGURE

2

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